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METHOD OF HANDLING HYDROGEN SULFIDE GAS IN THE ELK BASIN OIL FIELD OF WYOMING

BY

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METHOD OF HANDLING HYDROGEN SULFIDE GAS IN THE ELK BASIN OIL FIELD OF WYOMING[1]

By J. H. East, Jr.[2] and Ralph H. Espach[3]

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INTRODUCTION

The occurrence of hydrogen sulfide in the gas in solution in the oil produced from the Tensleep sandstone in the Elk Basin oil field in Wyoming constitutes a serious hazard to persons working in that field. Aware of the general conditions because of petroleum reservoir studies being conducted in that field by its engineers, the Bureau of Mines willingly agreed to a request of the Petroleum Administration for War to publicize the hazard and the measures for overcoming it. In October 1943 and November 1944, the Bureau of Mines investigated the methods used in handling the oil and in disposing of the hydrogen sulfide that occurs with it. This circular reports the results of these observations.

HYDROGEN SULFIDE OCCURRENCE IN THE ELK BASIN OIL FIELD

The Elk Basin oil field is in Park County, Wyo., and Carbon County, Mont. It is about 18 miles north of Powell and 12 miles west of Frannie, Wyo. The original Elk Basin oil and gas field was situated in an eroded depression surrounded by an inner rimrock about 200 feet high with a bordering higher plateau about 500 feet above the basin floor.

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[1] The Bureau of Mines will welcome reprinting of this report, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7334."

[2] Mining engineer, Bureau of Mines.

[3] Petroleum engineer, Bureau of Mines.

The original discovery of oil was made in the Frontier formation in 1915. The wells are relatively shallow (about 1,500 feet deep), and production form them approximated 11-1/2 million barrels of oil up to 1944. In 1922, the Cloverly formation was found to be productive of gas. The wells are about 2,500 feet deep and to the beginning of 1944 had produced approximately 30-1/2 billion cubic feet of gas. A drilling test of the deeper formations made late in 1942 revealed that the Tensleep sandstone contained oil in commercial quantities. Drilling has continued and, although more than 75 wells had been completed by the beginning of 1945, the oil-productive limits of the Tensleep structure have not been determined definitely. The wells at the top of the structure are about 3,900 feet deep, and the wells drilled on the flanks are as much as 6,000 feet deep. Drilling has proved definitely that the Tensleep sand will produce oil over the upper 2,000 feet of closure, indicating that the Elk Basin Tensleep oil reservoir is of major magnitude.

The oil in the Tensleep sandstone contains gas in solution, and when reduced to atmospheric pressure, large quantities of gas, ranging from 140 to 480 cubic feet per barrel of oil and containing high percentages of hydrogen sulfide, are liberated. If not handled properly, this condition is extremely hazardous for persons working or residing in the field. The amount of hydrogen sulfide in the gas varies with the relative position of the oil in the structure. There is less hydrogen sulfide in the gas as the oil comes from wells further down the flanks of the anticline. Samples of gas from the crest of the structure contain as much as 18 percent of hydrogen sulfide by volume, whereas those from near the oil limits on the flank contain as little as 6 percent.

The sources of hydrocarbon and hydrogen sulfide gases escaping into the atmosphere at Elk Basin and creating a hazard were leaky casing heads, valves, thief hatches on flow tanks, swabbing operations, bringing in and cleaning out new wells, and extinguishing flares where the gases are burned. In the early life of the field, men were overcome while gaging tanks and bringing in new wells and upon entering air currents having an appreciable hydrogen sulfide content. The hazard from gas escaping from the flow tanks where the oil is not under pressure may not be realized fully by those who are exposed to the hazard. The Bureau of Mines Petroleum and Oil-Shale Experiment Station at Laramie, Wyo., has determined that, although the gas from the oil near the top of the structure contains an average of 18 percent hydrogen sulfide, actually this gas as it comes out of solution as the pressure is reduced on the oil has a varying hydrogen sulfide content of 5 percent at pressures of 1,000 pounds to 35 percent at pressures of 50 pounds to atmospheric. Although the gas from the oil near the oil limits on the flank of the structure contains an average of 6 percent hydrogen sulfide, actually as it comes out of solution as the pressure is reduced on the oil this gas has a hydrogen sulfide content varying from 2 percent at pressures of 500 pounds to 10 percent at pressures of 50 pounds to atmospheric. Consequently, in field operations, when most of the pressure has been released the oil should be handled with every precaution if serious injuries and possible fatalities are to be avoided. This is applicable especially to tank gagers.

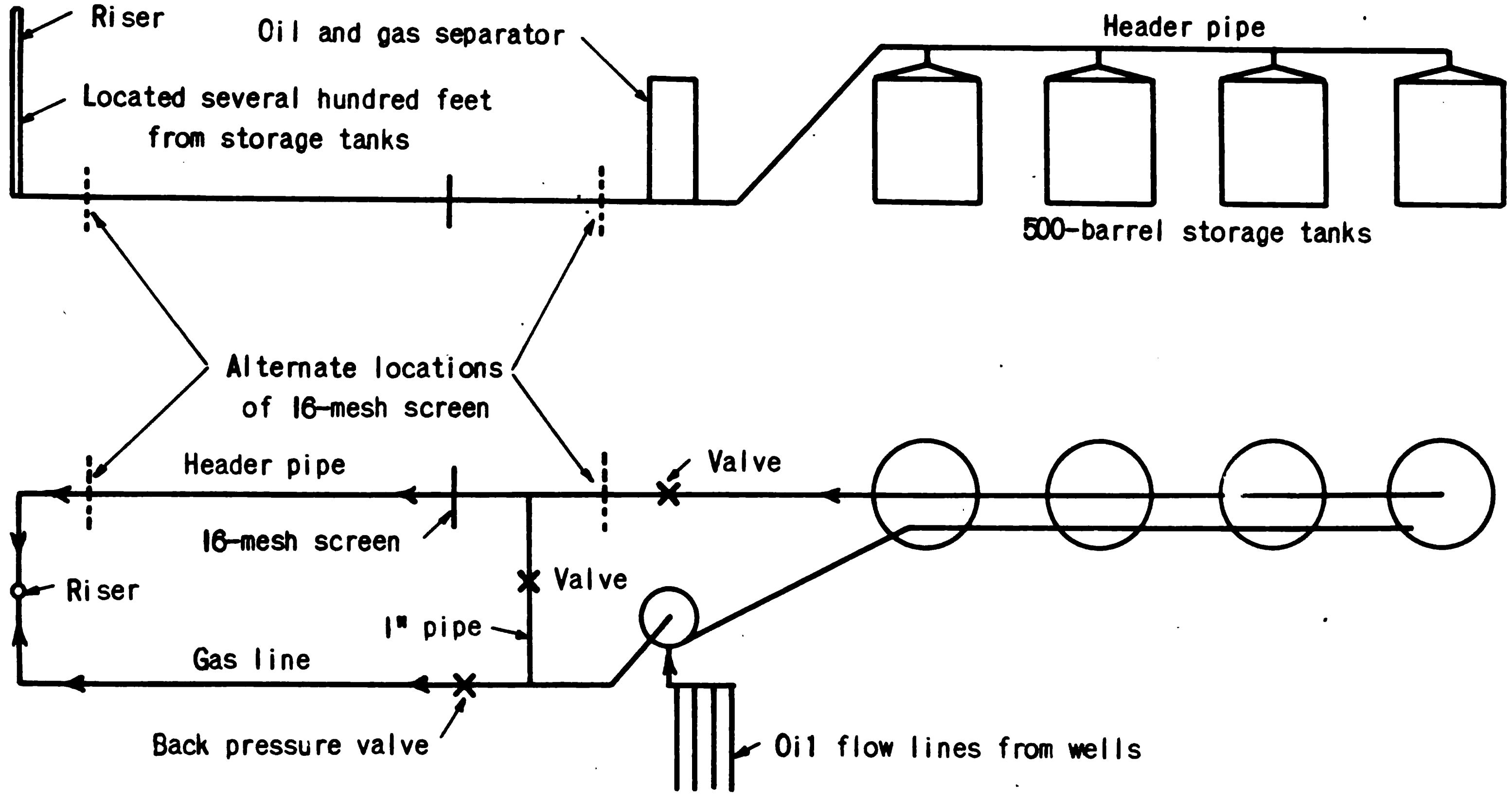

Figure 1.--A method of removing hydrogen sulfide from tank battery. Elk Basin oil field, Wyoming.

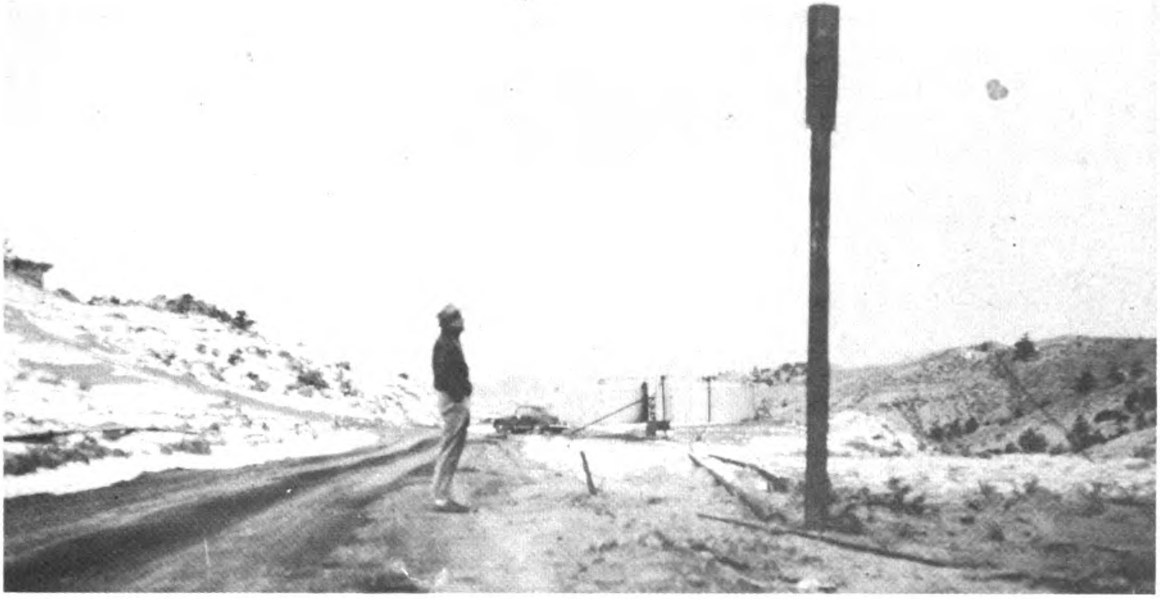

Figure 2. - Riser for burning gas drawn from top of storage tanks in background.

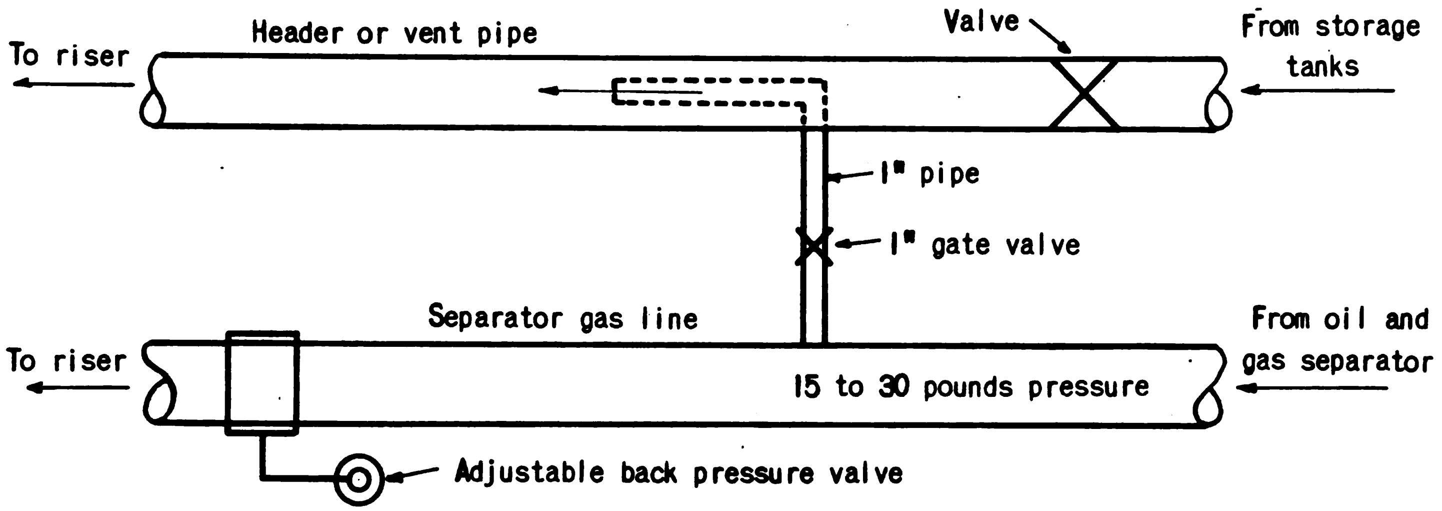

Figure 3.—Device to draw gas from top of tanks. Elk Basin oil field, Wyoming.

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METHODS USED IN HANDLING THE HYDROGEN SULFIDE-BEARING GAS

After much experimental work, the oil companies operating in the Elk Basin field have adopted an apparently satisfactory method of disposing of the gases containing hydrogen sulfide, as operations have been conducted in the field for more than 2 years without a serious injury or fatality from poisoning by hydrogen sulfide. One fatality occurred when a man fell from the fourble board in a drilling derrick after presumably being overcome by hydrogen sulfide gas. However, the fatality was attributable directly to failure to use a safety belt.

The standard practice at the Elk Basin oil field is to pipe the oil from all the wells on each lease through an oil and gas separator, which removes most of the gases from the oil, to a lease tank battery of 500-barrel steel tanks. Figure 1 is a sketch showing how the oil is handled. Each tank battery is connected to a pipe line, through which the oil is conducted to a pipe line pump station for pumping into the several pipe lines that transport the oil from the field.

Each tank of a battery is connected to a header pipe, generally at the highest point on the tank roof or deck, which is extended several hundred feet from the tank battery and is connected to a vertical pipe or riser used as a vent. This vent and equalizing header pipe usually are 4 inches in diameter. Figure 2 shows such a tank vent pipe and riser.

The gas line (usually of 4-inch pipe) from the oil and gas separator also extends to the foot of the vent riser. The practice of one company is to join the separator gas line and the tank vent pipe together into a 6-inch line near the separator and extend the 6-inch line to the riser several hundred feet from the tank battery.

A small pipe, usually 1 inch in diameter, is welded into the separator gas line and into the tank vent pipe, extending a foot or more ahead of the point of connection and in the center of and parallel to the tank vent pipe. Figure 3 is a sketch of this jet arrangement. Removable 16-mesh galvanized-iron screens are placed in the tank vent pipe between the tank battery and the riser. Placing of these screens has not been standardized, and several methods of screen installation are in use; all, however, provide for a larger cross-sectional area than that of the pipe.

The oil and gas separators are operated under pressures of 15 to 30 pounds per square inch, pressure being controlled by adjustable back-pressure valves. The valve is placed in the gas line from the separator at some point near the separator but beyond the 1-inch line that connects into the tank vent line. The gas in the 1-inch pipe is at the separator pressure, and because of its jetting action from the velocity of its discharge, a small suction or partial vacuum is created in the tank header pipe thereby drawing the gas from the tanks in the battery and delivering it to the riser. The jetting action is controlled so that the tanks are under a vacuum of about 1/2 ounce.

The riser for this type of lay-out usually consists of a 6-inch pipe 10 to 16 feet in height supported in a vertical position with a tee or welded header at the base, into which the tank vent pipe and the separator gas line are connected. The gas issuing from this riser is ignited, forming a flare, and thus the gas and hydrogen sulfide are rendered harmless. To keep the flares burning at some installations, the upper part of the riser is slotted for about 6 feet to permit air to mix with the gas while in the pipe; at other installations, a wind screen or hood (a 2-foot piece of 10-inch pipe open at top and bottom but welded to the riser by means of several fins) is placed at the top of the riser, and the gas is mixed with air inside the screen.

The operators realize that with a burning flare, if for some reason the pressure in the separator is released, causing the partial vacuum in the tanks to become a positive pressure, a possible flash-back explosion could occur that might ignite the oil in the tanks. A condition for a possible flash-back might result if the well were shut in without first closing a valve in the tank vent line leading to the flare, and if enough air had entered through the tanks to make an explosive mixture. The screens in the tank vent pipe are used to prevent such an explosion.

The present method of removing the gas from the top of the oil in the tanks and disposing of it contrasts sharply with the methods in use in 1943. At that time, attempts were made by some operators to burn the gas from the tank vent pipe without using additional gas from the separator, with the result that the flares would not burn continuously. The tank vent pipe and separator gas lines often were placed on the ground, and the gas was ignited at the end of the pipe several hundred feet away. At some installations, the gas from the tank vent pipe was allowed to escape into the atmosphere a short distance from the tank battery.

GAGING OIL TANKS

All the lease tanks observed were equipped with pressure and vacuum relief valves for 2 ounces pressure and 1/2 ounce vacuum. The tank gagers can operate the relief valve manually and determine whether the tank is under a vacuum before opening the thief hatch to gage the tank. Most of the operators have adopted an oil seal as an additional means of preventing the escape of gas from the tank while it is being gaged. One operator installs a vertical 4-inch pipe in each tank extending from the deck to near the bottom of the tank. This pipe, open to the atmosphere, is screwed into a flange on the deck and placed a few inches from the thief hatch. Oil in the pipe at approximately the same height as in the tank prevents the gas in the tank from entering the pipe. The gager measures the height of the oil in the tank by inserting the gage pole or tape into the pipe, and it is not necessary to open the thief hatch. The tanks of this operator are equipped with a float-type indicator, also, making it possible to observe the approximate height of the oil in the tank, thus reducing the number of gaging operations. Other operators equip the thief hatches with metal skirts or tubes that extend from the hatch almost to the bottom of the tank. The oil rises in the tube as the tank fills and prevents gas from the tank from escaping when the hatch is opened for gaging. One operator depends entirely on the vacuum created by the jetting action in the tank vent pipe to prevent gas from escaping from the tank.

Elk Basin operators generally have rules requiring tank gagers to wear gas masks while gaging tanks, but these rules are not strictly enforced. Most of the companies equip each gager with a gas mask for individual use.

PRECAUTIONS TAKEN WHILE BRINGING IN A WELL

When a new well is brought in, mud, water, and some oil are swabbed out of the well and discharged into a pit. If the well flows, these fluids are discharged into the pit for several hours, until the oil comes from the well clean enough to run to lease tankage. The oil discharged into the pit releases what gas is in solution and with it hydrogen sulfide. The winds in the area generally dissipate the gas, and care is taken that swabbing out is done only when the wind is blowing in a favorable direction; if the wind changes direction and men are imperiled, the work stops. Most of the operators block or guard roads across which the wind may carry hydrogen sulfide when a well is brought in or swabbed. Men working at neighboring wells are warned of the work in progress. Occasionally, on still nights, gas containing hydrogen sulfide may accumulate in low areas, especially above mud pits after bringing-in operations. Guards are used to patrol roads in the path of the moving body of gas to give warning if air currents should change. Gas masks are provided for all employees working at a well while it is being brought in or during swabbing operations. When bringing in a well, one operator uses a valve on the casing that can be opened or closed with a one-quarter turn of the handle. The valve can be operated from any direction and is fitted with a long handle that extends beyond the derrick.

OIL TANK-CAR AND TRUCK LOADING

Much was learned concerning the hazards of hydrogen sulfide in connection with loading railway tank cars and tank trucks with Elk Basin Tensleep oil. Loaders and truck drivers were overcome when they were exposed to the gases coming off of the crude oil at the loading manhole. On still nights, the gases rolled down from the manhole and accumulated around the trucks; in one instance gases accumulated in the truck cab and rendered the driver unconscious. To overcome these conditions, a 6-inch line about 500 feet long and ending in a 20-foot riser was laid, and a motor-driven exhaust fan was placed in the line. Two galvanized-iron, 16-mesh screens were placed in the line near the fan as protection against a flashback explosion when the gases issuing from the riser were ignited and burned. A canvas exhausting hood was placed over the manhole when the truck was being loaded, and the exhaust fan pulled the gases from the tank and discharged them to the flare.

GENERAL PRECAUTIONS[4]

Hose masks are used when the oil tanks are cleaned. The masks are not entirely satisfactory, because the wearers must be careful not to tangle and foul the air hose. One company is equipped with two 1-hour-type self-contained oxygen breathing apparatuses.

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[4] See Davenport, Sara J., Hydrogen Sulfide Poisoning as a Hazard in the Production of Oil: Bureau of Mines Inf. Circ. 7329, 1945, 10 pp.

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Hose masks also should be worn by employees while casing and capping a new well. Care should be taken that the air supply to the hose masks is not contaminated by hydrogen sulfide. The present company safety rule requiring employees to wear gas masks while gaging the contents of flow tanks should be enforced rigidly. WARNING: Canister-type gas masks do not protect against high concentrations of hydrogen sulfide. Hose masks should be worn when the concentration of hydrogen sulfide in the air exceeds 2 percent by volume.

The fact that there are few if any enclosed spaces around the wells and that usually a breeze is blowing to dissipate the gas constitute the greatest safety factors. Work at a well is done, so far as feasible, on the windward side, and in this way some of the danger of gas escaping from possible leaks is avoided.

Most companies hold safety meetings regularly, and constantly emphasize the hazard of hydrogen sulfide. It is believed that the psychological effect of these meetings has been beneficial in causing men to avoid accidents from this hazard.

Signs warning of possible danger from poisonous gases and hydrogen sulfide were observed at tank batteries, at wells, and at loading racks where the hazard exists. However, more of these signs could be used to advantage. Figure 4 shows such signs.

Two of the oil companies formerly maintained camps for their employees in the basin proper. The hydrogen sulfide hazard caused these companies to move the camps to a safer location on the plateau several miles south of the original site. Some shops still remain in the basin, but most of the residences, offices, and shops have been moved.

GENERAL RECOMMENDATIONS FOR THE PREVENTION OF HYDROGEN SULFIDE POISONING IN THE OIL FIELDS[5]

Owners of properties on which hydrogen sulfide gas is known to exist should post weather-proofed warning signs with this suggested text:

POISON GAS

> Oil and gas in this vicinity may contain enough hydrogen sulfide gas to cause unconsciousness or death.

Observe the following precautions under all conditions:

1. Always stand on the windward side of any opening from which gas is escaping.

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[5] Fowler, H. C., Prevention of Hydrogen Sulfide Poisoning in Handling and Refining High-Sulfur Petroleums: Bureau of Mines Rept. of Investigations 2847, 1927, 27 pp.

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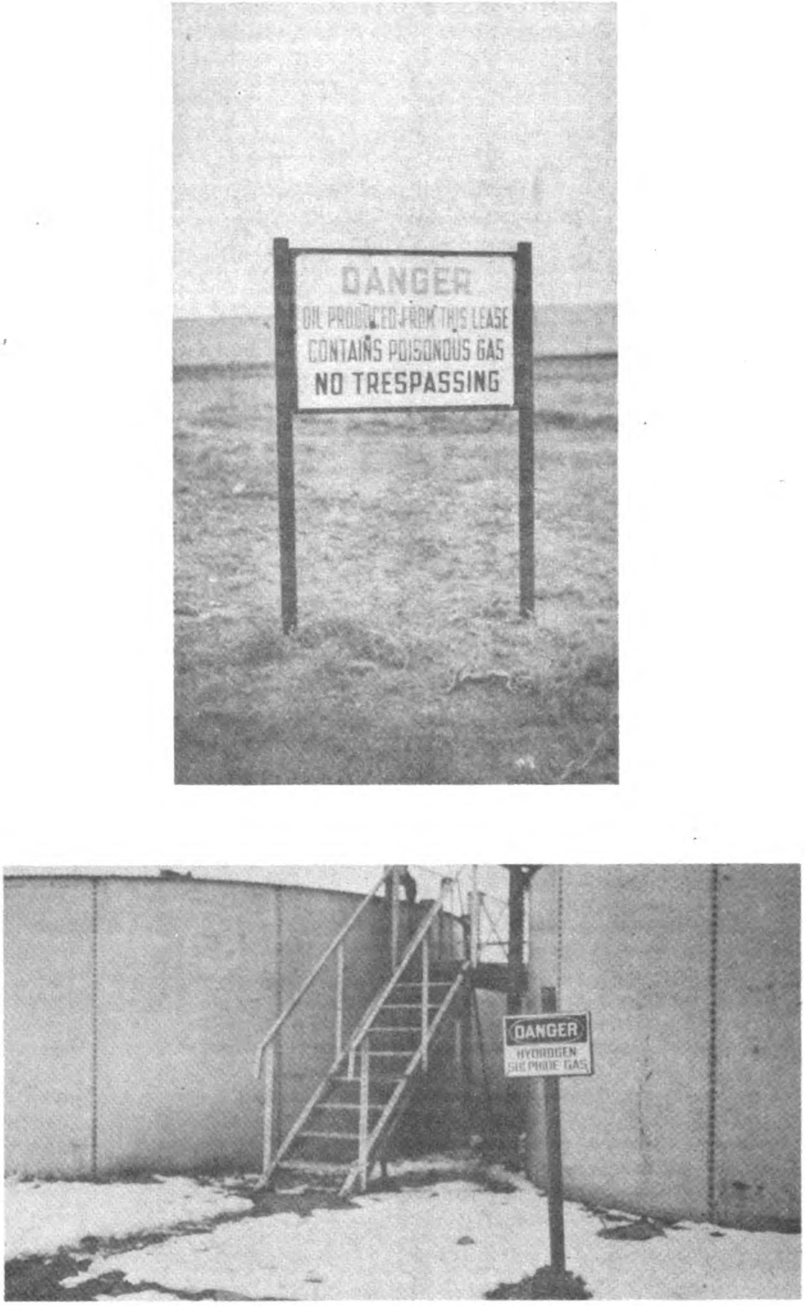

Figure 4. - Warning signs used at Elk Basin oil field.

2. Always wear a suitable gas mask, safety belt, and life line when entering a tank, cellar, or any other inclosed place where gas may accumulate.
3. Never attempt to determine the presence of harmful quantities of hydrogen sulfide gas by its odor.
4. When a break in a line occurs that may permit hydrogen sulfide gas to escape, hold the breath and leave the danger zone.
5. When a man is overcome, remove him to fresh air (using precautions for self protection); apply artificial respiration at once and call a doctor.

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